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ABSTRACT

Anxiety about statistics can result in impaired performance, mental anguish, and avoidance of statistics courses needed for professional advancement. The purpose of this study was to examine the relationship of the anxiety felt by students in graduate statistics courses to their characteristics and to the teaching strategies used by their instructors to reduce anxiety in the statistics classroom. Participants in the study were 178 students in graduate courses at the University of Southern Mississippi during the 1995-96 academic year. Multiple regression analysis revealed that 37% of the variability in the anxiety score on the Revised Mathematics Anxiety Rating Scale could be explained by the following variables: mathematics preparation, number of years since last mathematics course, perception of mathematical ability, proficiency in calculator use, computer anxiety, expected grade in department in which the course was taken, level of the course, major, age, gender, and teaching strategies for reducing anxiety in the statistics classroom, as measured by the Alleviating Statistics Anxiety Assessment. Independently, mathematics preparation, perception of mathematics ability, proficiency in calculator use, and gender were statistically significant predictors of statistics anxiety. (Contains 5 tables and 36 references.) (Author)

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Running Head: STATISTICS ANXIETY

Factors Related to Anxiety in the Graduate Statistics Classroom

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Paper presented at the
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Memphis, TN, November 12-14, 1997

Abstract

Anxiety about statistics can result in impaired performance, mental anguish, and avoidance of statistics courses needed for professional advancement. The purpose of this study was to examine the relationship of the anxiety felt by students in graduate statistics courses to their characteristics and to the teaching strategies used by their instructors to reduce anxiety in the statistics classroom.

Participants in the study were 178 students in graduate courses at the University of Southern Mississippi during the 1995-96 academic year. Multiple regression analysis revealed that 37% of the variability in the anxiety score on the Revised Mathematics Anxiety Rating Scale could be explained by the following variables: mathematics preparation, number of years since last mathematics course, perception of mathematical ability, proficiency in calculator use, computer anxiety, expected grade, department in which the course was taken, level of the course, major, age, gender, and teaching strategies for reducing anxiety in the statistics classroom, as measured by the Alleviating Statistics Anxiety Assessment. Independently, mathematics preparation, perception of mathematics ability, proficiency in calculator use, and gender were statistically significant predictors of statistics anxiety.

FACTORS RELATED TO ANXIETY IN THE GRAUDATE STATISTICS CLASSROOM

Mathematics anxiety has been described as "panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematics problem" (Hunt, 1985, p. 32). This fear of mathematics generalizes to statistics and causes otherwise competent people to experience intense feelings of incompetence and insecurity in the statistics classroom (Elmore and Vasu, 1980). Anxiety can have a debilitating effect. In addition to causing mental anguish, it can result in impaired performance, in avoidance of mathematics-related courses, and ultimately, in forfeiture of careers that require even a moderate amount of mathematics or statistics preparation (Richardson & Suinn, 1972).

For more than 20 years, researchers have explored the phenomenon of statistics anxiety. Some have linked it to lack of mathematics preparation (Elmore & Vasu, 1980; Perney & Ravid, 1990; Auzmendi, 1991). Others have examined the relationship of mathematics and statistics anxiety to age (Betz, 1978; Gourgey, 1984; Kosbab, 1989) and gender (Aiken, 1976; Betz, 1978; Fennema & Sherman, 1978; Feinberg & Halperin, 1978; Hendel & Davis, 1978; Fennema & Hart, 1994). There has been much research on the relationship of mathematics and statistics anxiety to other kinds of anxiety: general anxiety, situational anxiety, test anxiety, and anxiety about computer and calculator use.

Although there has not been a great deal of quantitative research on how teaching strategies affect anxiety in the classroom, many researchers have suggested ways to alleviate anxiety. Among these strategies are: addressing the anxiety (Tobias, 1978 and 1991; Dillon, 1982; Roberts & Saxe, 1982; Hunt, 1985; Yager & Wilson, 1986), using humor (Smith, Anscough, Ettinger, & Nelson, 1971; Kosbab, 1989; Schacht & Stewart, 1990), applying statistics to real-world situations (Yager & Wilson, 1986; Schacht & Stewart, 1992; Thompson, 1992; Stallings, 1993), reducing fear of evaluation (Hunt, 1985; Johnson, 1988; Kosbab, 1989), and encouraging students to work in small, cooperative groups (Burton, 1984; Blum-Anderson, 1992; Mealey and Host, 1992).

The intention of this study was to determine the relationship between a measure of the anxiety of students in graduate statistics courses and the variables mathematics preparation, number of years since last mathematics course, perception of mathematical ability, proficiency in calculator use, computer anxiety, expected grade, department in which the course is taken, level of the course, major, age, gender, and teaching strategies for reducing anxiety in the statistics classroom.

Variables were defined as follows:

Anxiety. A composite score of the subscales "Learning Mathematics Anxiety" and "Mathematics Evaluation Anxiety" of the Revised Mathematics Anxiety Rating Scale.

Mathematics preparation. number of previous mathematics courses completed.

Perception of mathematics ability. Self-rating from 0 to 100 to represent perceived mathematics ability in comparison to classmates.

Proficiency in calculator use. Self-rating from 0 to 100 to represent ability to perform statistics computations (mean, standard deviation, sums of squares) on a hand-held calculator.

Computer anxiety. Performance score on the Computer Anxiety Index.

Teaching strategies. Scores on the Alleviating Statistics Anxiety Assessment, which measures student reporting of teaching strategies intended to reduce anxiety in the statistics classroom: addressing the anxiety, using humor, applying statistics to real-world situations, reducing fears of evaluation, and encouraging students to work in small, cooperative groups.

Methodology

Participants

The participants in this study were 178 students enrolled in the graduate statistics courses in the College of Business Administration and the College of Education and Psychology at the University of Southern Mississippi during the 1995-96 academic year. Included were 72 males and 103 females, with three persons not reporting gender. The mean age was 32. The average participant had taken nearly seven previous mathematics or statistics courses, and it had been on average three years since the last mathematics or statistics class. Majors represented included business, psychology, social work, speech, communications, exercise physiology, human performance, educational administration, curriculum and instruction, special education, music education, science education, and adult education.

Data Collection

The research battery was administered to each class of students during a regularly scheduled statistics class meeting. Average completion time was 12 minutes. Although students were told that there would be no penalty for declining to participate in the study, there were no students who refused to participate. The only students not polled were those who were absent or excessively late or who had completed the survey in a previous class.

The research instrument consisted of four parts: (1) the Revised Mathematics Anxiety Rating Scale, (2) Biographical Information, (3) the Computer Anxiety Index, and (4) the Alleviating Statistics Anxiety Assessment.

Revised Mathematics Anxiety Rating Scale

The Revised Mathematics Anxiety Rating Scale (Revised MARS) (Plake & Parker, 1982) is a 24-item version of the Mathematics Anxiety Rating Scale (MARS). The original MARS, a five-point Likert scale containing 98 items, has been widely used as a diagnostic tool in the treatment of mathematics anxiety. Its test-retest reliability has been reported at .85 (Tryon, 1980). Coefficient alpha reliability has been estimated at .97 (Rounds & Hendel, 1980). A factor analysis of MARS (Rounds & Hendel, 1980) revealed two factors: Mathematics Test Anxiety, relating to learning, studying, or being tested about mathematics from a classwork perspective; and Numerical Anxiety, relating to day-to-day use of mathematics and computation.

Plake and Parker (1982) identified 24 items from MARS that measured anxiety in statistics courses and evaluated the resulting, statistics-specific subset (Revised MARS) in a study of 170 graduate students in introductory statistics classes at a large Midwestern university. The 24-item Revised MARS showed internal reliability with a coefficient alpha of .98. The correlation between the Revised MARS and the original MARS was .97. Factor analysis revealed two factors: (1) Learning Mathematics Anxiety (16 items) and (2) Mathematics Evaluation Anxiety (8 items).

Biographical Information

Biographical information relative to the following variables of the study was obtained by administration of a Biographical Information form:

1. Mathematics preparation
2. Number of years since last mathematics course.
3. Perception of mathematics ability.

4. Proficiency in calculator use.
5. Expected grade in the course.
6. Current Major
7. Age
8. Gender

Mathematics Preparation. Students indicated the number of courses they have completed from the following: high school Algebra I, Algebra II, Geometry, Pre-Calculus or Calculus, Trigonometry, and Advanced Mathematics ; College Algebra, Calculus, and Statistics/Probability. Each student's score was the total number of mathematics courses taken in high school and college.

Number of Years Since Last Mathematics Course. Students indicated the number of years since their last mathematics course. If it had been less than six months since their last course, they reported "0" for number of years since last mathematics course.

Perception of Mathematics Ability. Following Feinberg & Halperin (1978), participants were asked to place themselves on a scale from 0% (low) to 100% (high) to represent their perception of their relative position in mathematics competence in relation to the other students in their class.

Calculator Proficiency. Similarly, students placed themselves on a scale from 0% (low) to 100% (high) to represent their perception of their ability to perform statistics calculations (means, standard deviations, sums of squares) on a hand-held calculator.

Expected Grade. Students reported what grade they expected to get in the statistics course.

Major. Students reported their current academic major.

Age. Students were asked to give their current age in years.

Gender. Students were asked to indicate their gender (M or F).

The Biographical Information form was field-tested on 15 graduate students in Advanced Educational Research (REF 893).

Computer Anxiety Index

The Computer Anxiety Index (CAIN) developed by Simonson, Montag, Maurer, Oviatt, and Whitaker (1992) is a 26-item attitude survey designed to measure level of anxiety toward computer use. The authors define computer anxiety as "the fear or apprehension felt by individuals when they use computers or when they consider the possibility of computer utilization" (p. 12). The responses to the CAIN are on a 6-point Likert scale from "Strongly Agree to Strongly Disagree"; the higher the score, the higher the anxiety of the participant. Internal consistency reliability is reported by the developers of the instrument at .94; test-retest reliability is .90 (Simonson, Maurer, Montag-Torardi, & Whitaker, 1987).

Alleviating Statistics Anxiety Assessment

The Alleviating Statistics Anxiety Assessment was developed by the investigator to measure the extent to which statistics instructors use those teaching strategies purported in the literature to reduce anxiety in the statistics class: addressing anxiety, using humor, applying statistics to real-world situations, reducing fear of evaluation, and encouraging students to work in cooperative groups. The instrument includes 15 statements of teacher behavior, such as "My instructor addresses the topic of anxiety in the statistics class." Students reported their perceptions on a 5-point Likert scale ranging from "Strongly Agree" to "Strongly Disagree." The instrument was field tested using graduate students in Advanced Educational Research (REF 893). The major suggestion incorporated into the study was the inclusion of an open-ended question: "What strategies, if any, does your instructor use to reduce anxiety in the statistics classroom?" Three experts attested to the face and content validity of the instrument. Internal consistency was established on the instrument using the subjects of the study. Cronbach's alpha was .82.

A pilot study of the instrument involved the administration of the instrument to 37 graduate students in Testing and Individual Analysis (PSY 614). Cronbach's alpha was .55. Suggestions for additional statements focused on personality factors and were not incorporated into the instrument. One student in the pilot study wrote, "This subject is like taking medicine. It cannot be made palatable no matter how it is sugar coated. My instructor does as well as she can." A copy of the instrument is in the appendix.

Analysis of Data

Multiple regression analysis was used to test the relationship between anxiety of students in graduate statistics courses and the composite set of predictor variables mathematics preparation, number of years since last mathematics course, perception of mathematical ability, proficiency in calculator use, computer anxiety, expected grade, department in which the course is taken, level of the course, major, age, gender, and teaching strategies for reducing anxiety in the statistics classroom. A more parsimonious model was developed from variables that were shown to be highly correlated with the criterion variable anxiety.

Multiple regression analysis was also used to measure the relationship between the criterion variable anxiety and each of the independent variables: mathematics preparation, number of years since last mathematics course, perception of mathematical ability, proficiency in calculator use, computer anxiety, expected grade, department in which the course is taken, level of the course, major, age, gender, and teaching strategies for reducing anxiety in the statistics classroom. For each hypothesis, all variables other than the one to be tested were entered and a coefficient of determination (R^2) was obtained; the variable to be tested was then entered and a coefficient of determination for the full model was obtained. Significance and magnitude of effect (R^2 change) were thus determined for each variable while holding all other variables constant. The .05 rejection level was used for all tests of hypotheses.

Results

There were 73 males and 105 females who participated in the study.

Expected grades were: A, 125; B, 47; C, 2; and D, 1. Three participants declined to answer this question or gave a combination response (e.g., A/B).

Students had taken an average of 6.79 previous mathematics courses in high school and college, with 94% having had between three and eleven courses. It had been an average of 3.84 years since the last mathematics class, but nearly half had had a mathematics course within the past year.

Students rated themselves, on average, at the 77th percentile of students in their class on mathematical ability. The mode, however, was 90%, and the data shows a "ceiling effect." They rated themselves at the 82nd percentile in ability to use the calculator to perform statistics computations. The mode for this variable was also 90% and affected by the cap of 100%.

Scores on the Computer Anxiety Index ranged from 26 (lowest possible) to 124 (out of a possible 156). The mean was 53.66, and data were normally distributed.

Ages of the participants ranged from 21 to 55, with a mean of 32.24. The mode was 24.

Means and standards deviations for interval variables are given in Table 1.

Table 1

Means and Standard Deviations of Interval Variables: Mathematics Preparation, Number of Years Since Last Mathematics Course, Perception of Mathematical Ability, Proficiency in Calculator Use, Computer Anxiety, and Age

Variable	M	SD	N
Number of Mathematics Courses	6.79	2.81	177
Years Since Last Mathematics Course	3.84	6.30	178
Mathematical Ability	76.55	18.22	177
Proficiency in Calculator Use	82.11	20.37	176
Computer Anxiety	53.66	20.21	175
Age	32.24	9.74	175

Alleviating Statistics Anxiety Assessment

Scores on the Alleviating Statistics Anxiety Assessment ranged from a minimum of 33 to a maximum of 54, with a mean of 41.72 and a standard deviation of 3.88. Data were distributed normally. Since the instrument used a 5-point Likert scale (1= "Strongly Agree" and 5= "Strongly Disagree") and contained 15 questions, the average response was 2.73, close to the "Neither Agree nor Disagree" point and leaning slightly toward the "Agree" point. On average, respondents "slightly agreed" that their instructors employed strategies to reduce anxiety in the statistics classroom.

Revised Mathematics Anxiety Rating Scale

Scores on the Revised Mathematics Anxiety Rating Scale ranged from a low of 24 to a high of 112 in a possible range of 24 to 120. The mean score was 54.06 with a standard deviation of 19.19. Data were normally distributed. The average score per item was 2.25 on a 5-point scale (1= "Not at all," 2= "A little," 3= "Moderate," 4= "Much," and 5= "Very Much"), showing that the average amount of anxiety felt in each hypothetical situation was "a little" and leaning toward "moderate."

For the 16 items concerning anxiety in statistics learning situations, the average score per item was 1.97. For the eight items concerning testing, the average score per item was 2.82. All predictor variables were entered into the multiple regression analysis, resulting in an $\underline{F}$ ratio of 6.36 and a significance level $<.05$ ($n=151$). There is a significant relationship between anxiety and the predictor variables. Magnitude of effect, as measured by the coefficient of determination (R^2), was 0.37. Summaries of the regression analysis are found in Table 2 and Table 3.

Table 2

Relationship between Anxiety and the Variables of Mathematics Preparation, Number of Years Since Last Mathematics Course, Perception of Mathematical Ability, Proficiency in Calculator Use, Computer Anxiety, Expected Grade, Department in which Course is Taught, Level of Course, Major, Age, Gender, and Teaching Strategies (N=151)

	df	Sum of Squares	Mean Square	F
Regression	13	19769.52	1520.73	6.36*
Residual	137	32740.41	238.98	

Note. $R^2 = .37$. *$p < .001$.

Table 3

Summary of Regression Analysis for Variables Predicting Anxiety (N=151)

Variable	B	SE B	Beta
Mathematics Preparation	-1.69	0.52	-.26**
Years Since Last Mathematics Course	-0.06	0.24	-.02
Mathematical Ability	-0.20	0.09	-.19*
Calculator Proficiency	-0.19	0.08	-.20*
Computer Anxiety	-0.02	0.07	-.03
Expected Grade	-4.88	2.76	-.14
Department	-.02	0.96	-.00
Level of the Course	-3.53	3.23	-.10
Major	-0.53	0.52	-.08
Age	0.15	0.17	.07
Gender	5.58	2.66	.15*
Teaching Strategies	0.02	0.17	.01

Note. A higher score indicates higher anxiety. $R^2 = .37$. *$p < .05$. **$p < .01$.

A more parsimonious regression model was developed using those variables that were highly correlated with statistics anxiety as measured by the Revised Mathematics Anxiety Rating Scale: perception of mathematics ability, mathematics preparation, proficiency in calculator use, expected grade, and gender. The revised model produced an F ratio of 16.52 with a significance level of .0000. The coefficient of determination was .36, just one point below the original model. Summaries of the regression analysis are shown in Table 4 and Table 5.

Table 4

Relationship between Anxiety and the Variables of Mathematics Ability, Mathematics Preparation, Calculator Use, Expected Grade and Gender (N=151)

	df	Sum of Squares	Mean Square	F
Regression	5	19055.14	3811.03	.00*
Residual	145	33454.79	230.72	

Note: R^2=.36. *p < .001.

Table 5

Summary of Regression Analysis for Variables Predicting Anxiety: Parsimonious Model (N=151)

Variable	B	SE B	Beta
Mathematics Ability	-0.19	0.08	-0.19*
Mathematics Preparation	-1.98	0.47	-0.30**
Calculator Use	-0.16	0.67	-0.18*
Expected Grade	-5.24	2.58	-0.15*
Gender	5.57	2.57	0.15*
Constant	106.18	10.95	

Note. R^2 = .36. *p < .05. **p < .001.

Separate regression models were constructed to determine the independent relationship between anxiety and each of the predictor variables. There were significant independent relationships between anxeity and the variables mathematics preparation, mathematical ability, calculator proficiency, and gender (Table 5).

Table 5

Coefficient of Determination for Full and Restricted Models, R^2 Change, and Level of Significance for Tests of Independent Relationships between Anxiety and the Predictor Variables

Variable	R^2 Full	R^2 Restricted	R^2 Change
Mathematics Preparation	0.37	0.32	0.05**
Years Since Last Course	0.37	0.37	0.00
Mathematical Ability	0.37	0.35	0.03*
Calculator Proficiency	0.37	0.35	0.02*
Computer Anxiety	0.37	0.37	0.00
Expected Grade	0.37	0.36	0.02
Department	0.37	0.37	0.00
Level of Course	0.37	0.37	0.00
Major	0.37	0.37	0.00
Age	0.37	0.37	0.00
Gender	0.37	0.35	0.02*
Teaching Strategies	0.37	0.37	0.00

Note. Discrepancies are due to rounding error. *$p < .05$. **$p < .001$.

Discussion

This study shows, as have many others, that predicting levels of anxiety in statistics students is not an easy proposition. Typically, more than half the variance in anxiety scores is unexplained. In this study, the predictor variables accounted for 37% of the variance. In a study of mathematics anxiety in older students, Gourgey (1984) was able to explain 40% of the variance in anxiety scores with measures of beliefs about mathematics, mathematical self-concept, and arithmetic skills. Auzmendi (1991) included other measures of anxiety, both state and trait, as well as expectations of success, perception of mathematical ability, number of years of high school mathematics, grade expectations, and confidence with computers in a study of introductory statistics students; coefficients of determination were .40 at the beginning of the term and .48 at the end of the term.

The finding of mathematics preparation as an important determinant of anxiety in statistics students confirms the research of Betz (1978), Feinberg and Halperin (1978), Roberts and Saxe (1982), Harvey, Plake, and Wise (1985), and Perney and Ravid (1990). More adequate mathematics preparation is inversely correlated with mathematics and statistics anxiety. The question of causality remains: Are students less anxious because they have taken more mathematics? Or have they taken more mathematics because they are less anxious?

The significance of a self-rating of mathematical ability as a predictor of anxiety in statistics courses was similarly discovered by Feinberg and Halperin (1978). Auzmendi (1991) also found subjective perception about mathematical ability to be an important predictor of anxiety, both at the beginning and at the end of the statistics course. An important question to ask is whether a self-rating of ability is a measure of true ability or rather a measure of attitude and self-confidence. Feinberg and Halperin (1978) found that while mathematical ability, as measured by a basic skills test rather than a subjective rating, was positively correlated with performance, it was not correlated with anxiety.

The relationship between anxiety and calculator proficiency has not been found elsewhere in the literature. Although Roberts and Saxe (1982) found a positive correlation between attitudes toward calculators and attitudes toward statistics at the beginning of the term, there has been no previous research concerning ability to use the calculator. This finding may be useful to statistics instructors.

The finding of gender as a predictor of statistics anxiety mirrors the research of Betz (1978) and refutes that of Resnick, Viehe, and Segal (1985) and Harvey, Plake, and Wise (1985). In a multiple regression analysis study using only those students above the introductory level, gender was not a significant predictor of anxiety.

Like the research of Hendel and Davis (1978) and Harvey, Plake, and Wise (1985), this study showed no relationship between anxiety and the number of years since the last mathematics course. Similarly, there was no significant relationship between age and anxiety. At least for this population, the older student--even the older student far removed from the last mathematics class--felt no more anxious than the younger ones.

Surprisingly, there was no significant independent relationship between statistics anxiety and computer anxiety as measured by the Computer Anxiety Index. This finding contradicts the anecdotal evidence of the computer lab and may be a function of the instrument rather than a reflection of reality. The Computer Anxiety Index may be a bit outdated for today's computer-savvy students; it may also be too general for use in research on statistics anxiety. A more situational test, centered on those problems encountered in running statistics software on a mainframe or personal computer, may have better measured computer anxiety in the statistics course.

Unlike the work of Feinberg and Halperin (1978) and Auzmendi (1991), this study revealed no significant relationship between expected grade and anxiety. With more than 70% expecting a grade of "A" for the course, perhaps it is no wonder that grades were not anxiety producing.

Both Betz (1978) and Auzmendi (1991) found level of the course to be predictors of anxiety. This study, however, showed no such relationship. The tiny percentage (<.02) of participants enrolled in upper level courses may have affected this finding. Because of course requirements, many of the same people take both the introductory and intermediate classes, thus negating any "winnowing out" effect. Perhaps, too, because the participants were graduate students with most of their educational backgrounds behind them, their level of anxiety was "set" before embarking on the courses surveyed here.

This study shows that there is no relationship between anxiety and many of the anxiety-reducing techniques teachers use in the classroom: acknowledging the anxiety, using humor, applying statistics to real-world situations, promoting cooperative learning, and test preparation. It seems obvious from the results of this study that the Alleviating Statistics Anxiety Assessment is in its infancy.

Implications for Educators

The results of this study have implications for educators, particularly administrators and instructors involved in providing statistics education to graduate students. First, students come to statistics classes with a great deal of previous knowledge and experience, with beliefs about their abilities and disabilities, with the ideas, values, and opinions that make up each unique personality. They are anything but *tabula rasa*, waiting for the sharp stylus of an instructor's information and insight. What they bring to the classroom is indeed more powerful in predicting their anxiety than anything teachers can do to prevent it. In particular, instructors can anticipate that students who have less mathematics preparation and who feel that their mathematics ability is less than that of their classmates will experience higher feelings of anxiety in the statistics classroom.

Secondly, departments can encourage, and even require, background courses that prepare students mathematically for studying statistics. They can particularly require evidence of introductory knowledge before students are permitted to take intermediate courses.

Students can be provided with training in the use of the hand-held calculator to perform statistics calculations. Instructors may assume that students are proficient; in this study, the average student--who expected an "A"--ranked himself or herself at only 82% in calculator proficiency.

Institutions can provide tutoring services for students in statistics courses. Remedial mathematics, as well as calculator use, may be offered.

Finally, instructors can incorporate into their classes those strategies that students suggest for reducing anxiety. Each class's preferences, in addition to the wisdom of researchers and theoreticians, may provide insight into the challenge of reducing anxiety in the statistics classroom.

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